

Application of Polymer Materials in Food Packaging

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Abstract— *The polymer packaging is firmly established in our lives, today it is difficult to imagine that at the beginning of the last century there have were no plastic products. The successful development of polymeric packaging materials for long-term storage of food in the food industry is happening due to the efficiency of the polymers and their production is a relatively inexpensive and practical one. With their minimum weight and cost, the polymeric packaging materials (films) while effectively retaining high quality of the food products in selling goods for a long time are to maximally facilitate opening, cooking and consuming the said products.*

Keywords— Polymer, packaging, food, materials

I. Introduction

Various pests expose agriculture and food products to attack from storage until consumption by consumers. Insects and fungi are the most serious pests that can contaminate food products in warehouses. Despite modern food and other agricultural products storage and distribution systems, most packaged food products, with the exception of canned and frozen goods, are subject to attack and penetration by insects (Mullen & Highland, 1988). When a packaging containing one of insect life stages enters into storages (infested packaging), it could cause the prevalence of infestation. In addition to reducing food quantity, insects annihilate quality, too. By nourishing into the foods, they prepare the conditions for the attack by pathogen microorganisms, such as fungi and as such, the consumption of these foodstuffs could be followed by dangerous present day diseases e.g. cancer types as contaminated foods to pathogens like fungi are one of the most important problems in the industry of storage foods and they are susceptible to mycotoxins (Jakic-Dimic et al., 2009). There are few categories of mycotoxins regarding their chemical structure, sensitivity of certain organs and origin of fungi that produce them. Aflatoxin is a secondary metabolite produced by *Aspergillus flavus* (Lopez-Diaz & Flannigan, 1997). Aflatoxin is potential to cause liver damage, cirrhosis, and liver cancer and

aflatoxin B1 is the most dangerous toxin for animal and human health (Syarief et al., 2003). So, huge losses have been observed in agriculture produce and different ways are designed for controlling stored-product pests. Storing foodstuffs in bulk or sacks is a usual method for controlling pests without application of chemical methods. These sacks are made of different materials such as sheeted polymers used for packaging agricultural products to prevent the entrance of pests and contaminations (Allahvaisi, 2009). Wastage varies from 5-35% depending on nature of crops. Majority of wastage takes place in each of the steps viz. storage, transportation and at retail market due to improper packaging. Bulk Packaging made of polymers provides a solution for commodities weighing 10-50 kg during handling, storage and transportation, while smaller packaging for food products range from 50 ml to 5kg. Polymeric packaging fulfils the diverse role from protecting products, preventing spoilage, contamination, extending shelf life, ensuring safe storage thereby helping to make th readily available to consumers in our day to day life. This chapter will be a very helpful to all its readers, entrepreneurs, scientists, existing industries, technical institution, etc in the field of packaging (Anonymous, 2011).

II. Material and Methodology

Today, several polymer types are currently used for foodstuff packaging. Plastics have emerged as the most preferred choice of packaging materials for various products- from food, beverages, chemicals, electronic items and so on. They offer unique advantages over conventional materials (Anonymous, 2011):

□ Safety: Plastics are safer materials for packaging of food products specially polyolefins which do not react with food. Pilferage and contamination is difficult.

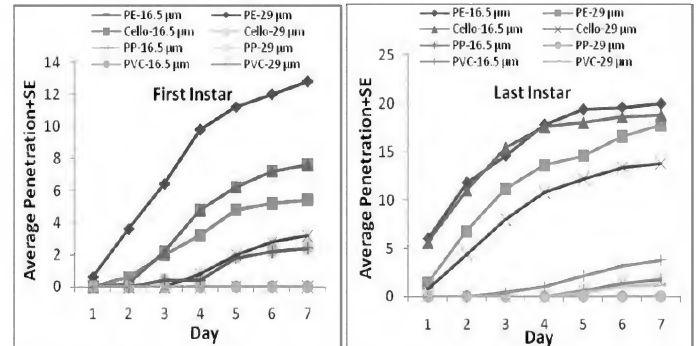
- Shelf Life: Plastics packaging material offer better shelf life
- Cost: Plastics are the most cost effective medium of packaging when compared with any other material, the cost of transportation is reduced considerable on account of lower weight and less damage
- Convenience: Plastics can be converted in any form with various processing techniques, thus can pack any type of substances like liquids, powders, flakes, granules, solids.
- Waste: Packaging in plastics reduces the wastage of various food products, typical example is potatoes or onions packed in leno.
- Aesthetics: A right choice of plastics packaging increased the aesthetic value of products and helps in brand identity
- Handling and Storage: Products packed in plastics are easiest to handle and store as well as transport.
- Plastic products are easy to recycle.

Every day there are new products packed in plastics replacing conventional products and when a thought is given to pack a new product the first choice appears in the mind is Plastic packaging material.

Polymeric films have the most application in industry and are used in many packaging applications specially greenhouse and agricultural. In agricultural products that is the important subject in packaging, there are specific products include cereal, spices, edible oils, drinking water, chocolate and confectionery, fruits and vegetables, marine products and many more. So, there are various food items those are effectively and economically packed in various types of plastic packaging materials.

Although finished products can be shipped from production facilities uninfested, stored product insects can enter packaged goods during transportation, storage in the warehouse, or in retail stores. As from storage to consumption by consumers, the agriculture products are exposed to attack by pest insects. Insects are the most serious pests that can contaminate the food by penetration of products in warehouses. The packaging of products is the last line of defense for processors against insect infestation of their finished products. There are two types of insects that attack packaged products: “penetrators”, which are insects that can bore holes through packaging materials; and “invaders”, which are insects that enter packages through existing holes,

such as folds and seams and air vents (Highland, 1984; Newton, 1988). The most insects use their sense of olfaction to find food. The foodstuffs packages are made of different materials such as sheeted polymers which are used for packaging the agricultural products in order to prevention of entrance of pests. Consumer-size food packages vary considerably in their resistance to insects. Sometimes the contamination was created by entrance of one infested package. When neglected, such an infestation will serve as a source of infestation for other commodities in the storage area. So, the packaging polymers should not only be resistance to insects, but also should be permeable to gases used for disinfecting in stores. Thus, the polymer thickness and manner of placing packages in storage should be corrected to prevent serious damage in the products (Cline, 1978). Although, the polymer's kind is more important than thickness. In a study determined that the difference between thicknesses of 16.5 and 29 μm is significant (Fig. 1). This figure shows that the ability of species to penetrate materials may vary between life stages (Allahvaisi,2010).



(PE=polyethylene, PP=polypropylene, PVC=polyvinylchloride and Cello=cellophane)

Fig. 1. Number of first and last instar larvae of *S. cerealella* that penetrated tested polymeric pouches with two thick in lack of food conditions during 7-d period As, remaining constant and subsequently decreasing the slope of the curves at insects' penetration last days (after maximum penetration) prove that insects always attempt to penetrate new food packages and their high activity is for availability to more food sources. In bottom table you see the permeability percentage of four current polymers for packaging foodstuffs in two thicknesses to some stored-pest insects starved.

In addition to improving the packaging material and design, insect repellents are used to prevent insects from entering packages by modifying the behavior of insects (Highland, 1984; Mullen, 1994; Watson and Barson, 1996; Mullen and Mowery, 2000). Pyrethrins synergized with piperonyl butoxide were approved for use as a treatment for insectresistant packaging on the outer layer of packages or with adhesive in the USA (Highland, 1991). The repellency of pyrethrins was the primary mode of action against insect penetration and invasion (Laudani & Davis, 1955). Methyl salicylate, an insect repellent, has been registered to be used in food packaging to control stored-product insects in the USA (Radwan & Allin, 1997). DEET, neem, and protein-enriched pea flour are repellent to manystored-product insects when tested by exposure on filter paper or in preference chambers (Khan & Wohlgemuth, 1980; Xie et al., 1995; Fields et al., 2001). Included in the construction of the multiple-wall bags was a barrier layer that prevented the migration of repellents into the foodstuffs. So, a resistant polymer to insect's penetration with a repellent of pests is the most suitable cover for packaging because it can prevent insect penetration and can be as a safe method for IPM programs which could in further reduce the application of the synthetic chemical pesticides and prevent the infestation of the stored-product pests. In some researches polypropylene polymer films are introduced as a suitable polymer with repellent for controlling the pest insects of stored-products.

III. Results and Tables

Research performed by Hou and colleagues (2004) showed that the repellents such as DEET reduce the number of insects entering the envelopes (Table 2).

Insect	Number of insects		χ^2	P
	Treated	Untreated		
<i>Sitophilus oryzae</i>	270.3	18973	735.82	<0.0001
<i>Tribolium castaneum</i>	1773	10178	197.88	<0.0001
<i>Cryptolestes ferrugineus</i>	470.7	117728	354.1	<0.0001
<i>Oryzaephilus surinamensis</i>	1173	10078	246.77	<0.0001
All insects	3475	507731	1481.56	<0.0001

Table 3. Number of insects (\pm SEM) in envelopes treated with DEET at 50 ml/envelope, 1 week after insects were released (n = 4)

CO ₂ gas insects' penetration in polymeric packagings (Average \pm SE)								
Polymer	Polyethylene		Cellophane		Polyvinyl chloride		Polypropylene	
	16.5	29	16.5	29	16.5	29	16.5	29
Thickness (μ m)	1.3 \pm 0.013	0.44 \pm 0.004	1.28 \pm 0.01	0.443 \pm 0.005	0.4 \pm 0.012	0.23 \pm 0.004	0.73 \pm 0.004	0.32 \pm 0.007
	a	b	a	c	d	f	c	e

Table 2. The tested polymers to mean permeability the polymers to CO₂ gas Plastics based on Polypropylene, Polyethylene, Polyvinyl Chloride and Cellophane, hugely used for packagings, has some of these properties but this is different at them. For example,these polymers rank generally from the easiest to the most difficult to penetration against insect pests; Cellophane, polyethylene, Polyvinylchloride and Polypropylene. The least penetration is carried out in PP and PVC polymers. Foodstuffs packaged by polymer films of PP and PVC could provide the conditions and so, by suitable packaging the stored pest insects do not access to food and without food they become extinct. But in the comparison between polypropylene and polyvinylchloride, PVC isn't a safe polymer for packaging foodstuffs in order to release HCl gas and the only importance of PVC in storage industry is often to be used as a gas-tight cover on agricultural products to keep a suitable concentration of gas and it is important for controlling quarantine pests. Furthermore, other two polymers, Polyethylene and Cellophane have a high permeability to gases but a very low resistance to pests as the product packaged into them becomes more contamination than ones into PVC and PP. The polymer films of Polyethylene and Cellophane; specially Cellophane, is greatly used for packaging the products be consumed daily. Moreover, Cellophane is 100% biodegradable. Some studies show that polypropylene had a good degradability in environment in comparative to polyethylene and polyvinylchloride. Also, new studies show that polypropylene has a suitable property for coating with nano metals and repellents for decreasing the losses of stored-products in effect of pest infestation. Hence, according to the investigations of researchers (in above) polypropylene usually is used as a suitable cover for packaging foodstuffs in stores and has perfect physical and chemical properties for the packaging works which should be performed in stores of maintaining foodstuffs.

III. Conclusion

According to the results of performed works in the field of packaging, it is proved that a polymeric cover usually made of polypropylene with thickness <100 µm is the most suitable one for foodstuffs packaging.

Acknowledgement

Total words should not be more than 50 words
(Times New Roman, 10).

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